RI 9245

REPORT OF INVESTIGATIONS/1989

Computer Modeling of Continuous Miner Cutting Systems for Dust Generation

By B. D. Hanson and W. W. Roepke

BUREAU OF MINES

UNITED STATES DEPARTMENT OF THE INTERIOR

Mission: As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally-owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. Administration.

Report of Investigations 9245

Computer Modeling of Continuous Miner Cutting Systems for Dust Generation

By B. D. Hanson and W. W. Roepke

UNITED STATES DEPARTMENT OF THE INTERIOR
Manuel J. Lujan, Jr., Secretary

BUREAU OF MINES
T S Ary, Director

Library of Congress Cataloging in Publication Data:

Hanson, Bruce D.
Computer modeling of continuous miner cutting systems for dust generation.

(Report of investigations; 9245)

Includes bibliographical references.

Supt. of Docs. no.: I 28.23:9245.

1. Coal-mining machinery–Testing–Computer programs. 2. Mine dusts–Analysis–Computer programs. I. Roepke, Wallace W. II. Title. III. Series: Report of investigations (United States. Bureau of Mines); 9245.

TN23.U43 [TN813] 622 s [622'.8] 88-607918

CONTENTS

ILLUSTRATIONS

TABLES

UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

hp	horsepower	mg/m^3	milligram per cubic meter
in	inch	mg/st	milligram per short ton
in/r	inch per revolution	pct	percent
in/s	inch per second	rpm	revolution per minute
lbf	pound (force)	st	short ton
lbf/ft	pound (force) per foot	yr	year
m^3	cubic meter		

COMPUTER MODELING OF CONTINUOUS MINER CUTTING SYSTEMS FOR DUST GENERATION

By B. D. Hanson[1] and W. W. Roepke[2]

ABSTRACT

The U.S. Bureau of Mines has developed an interactive computer program which enables the user to identify the effect of cutting system changes on relative dust generation and forces for continuous miner drums. The program simultaneously evaluates machine and coal seam parameters, and those parameters which the user can control. One or more of these parameters may be changed to determine their individual or collective effect on relative dust generation and cutting forces. The program is written in the BASIC programming language. A complete program listing is included along with user instructions and sample outputs.

[1]Physical scientist
[2]Supervisory physical scientist.
Twin Cities Research Center, U.S. Bureau of Mines, Minneapolis, MN.

INTRODUCTION

Since the enactment of the Federal Coal Mine Health and Safety Act of 1969, the U.S. Bureau of Mines has conducted an extensive research program on the control and reduction of respirable coal dust. Over the past 15 yr, research has been conducted in small-scale laboratory tests, in intermediate-sized prototype tests, and in full-scale in-mine demonstrations. The main objective of the work at the Bureau's Twin Cities (MN) Research Center has been the determination of the effect of controllable machine parameters on respirable dust generation. These controllable parameters include depth of cut, bit spacing, bit geometry, and operating conditions.

The body of data collected during this research provides a broad base of knowledge on the coal cutting phenomenon. The results are available to the industry in the form of a multitude of Bureau publications. There is so much information in so many places that individuals interested in reducing respirable dust generation at a specific mining operation will have difficulty finding their way through the available data to extract the specific information they need. The advent of the microcomputer and its universal availability provides a means of alleviating this problem.

This report presents a version of the cutting system model (CSM)[3] specifically structured for the analysis of continuous mining machines (CM-CSM).

PROGRAM DESCRIPTION

The CM-CSM program was developed to analyze the relative dust generated by a continuous mining machine cutting in a coal seam containing rock band or middle man. The program is menu driven, allowing the user to make parametric changes with a minimum of steps. It is written in BASIC and will run on an IBM[4] Personal Computer or equivalent. The menus through which the program operates allow the user to change parameter values, calculate dust values, save modified data files, obtain printer copies of summary reports, lists of modifications, and a listing of the entire data file. Also, a "Help" menu provides online assistance to the user. A program listing is given in appendix A. The parameters used are defined in appendix B.

The logical flow of the program is shown in figure 1. The program first determines the angle of contact between the drum and the coal face. At the start of sump this angle will be 90° and will increase as the sump cut is made. An average cut depth will be calculated based on either the user specified maximum sump rate or shear rate for each vertical strata (coal, rock, coal) through which the drum is cutting. This average cut depth is calculated based on the analysis of rotary cutting performed by Roepke.[5]

The equation used is

$$\text{average depth} = \int_{\phi_1}^{\phi_2} D(\phi)\, d\phi \;/\; (\phi_2 - \phi_1),$$

where ϕ_1 = angle at entry,

ϕ_2 = angle at exit,

$D(\phi) = R + A\cos(\phi) - (R^2 - A^2\sin^2(\phi))^{1/2}$ unless $D(\phi) > D_{max}$, in which case

$D(\phi) = D_{max}$,

R = drum radius,

A = advance per revolution,

D_{max} = maximum cut depth due to bit interaction,

and ϕ = rotation angle about drum center.

Once the average cut depth is calculated, the cutting and normal forces will be computed. Both the cutting and normal forces are assumed to be linear functions of depth. The force equations are defined by a slope and intercept, which can be obtained from either laboratory cutting tests or from in situ measurements with the in-seam tester.[6] The effect of bit wear is incorporated by the application of multipliers to both the cutting and normal forces. For new bits (e.g., wear equal to 0 pct), the multiplier is 1. A maximum of three different wear stages can be used by the

[3]Roepke, W. W., B. D. Hanson, and R. L. Schmidt. Computer Program To Relate Dust Generation to Drum-Type Coal Mining Machines. BuMines RI 8979, 1985, 30 pp.

[4]Reference to specific products does not imply endorsement by the U.S. Bureau of Mines.

[5]Roepke, W. W., D. P. Lindroth, and T. A. Myren. Reduction of Dust and Energy During Coal Cutting Using Point Attack Bits. BuMines RI 8185, 1976, 53 pp.

[6]Roepke, W. W., and J. C. Church. Measuring In-Seam Coal Cutting Forces. Min. Eng. (N.Y.), v. 35, No. 9, 1983, pp. 1281-1286.

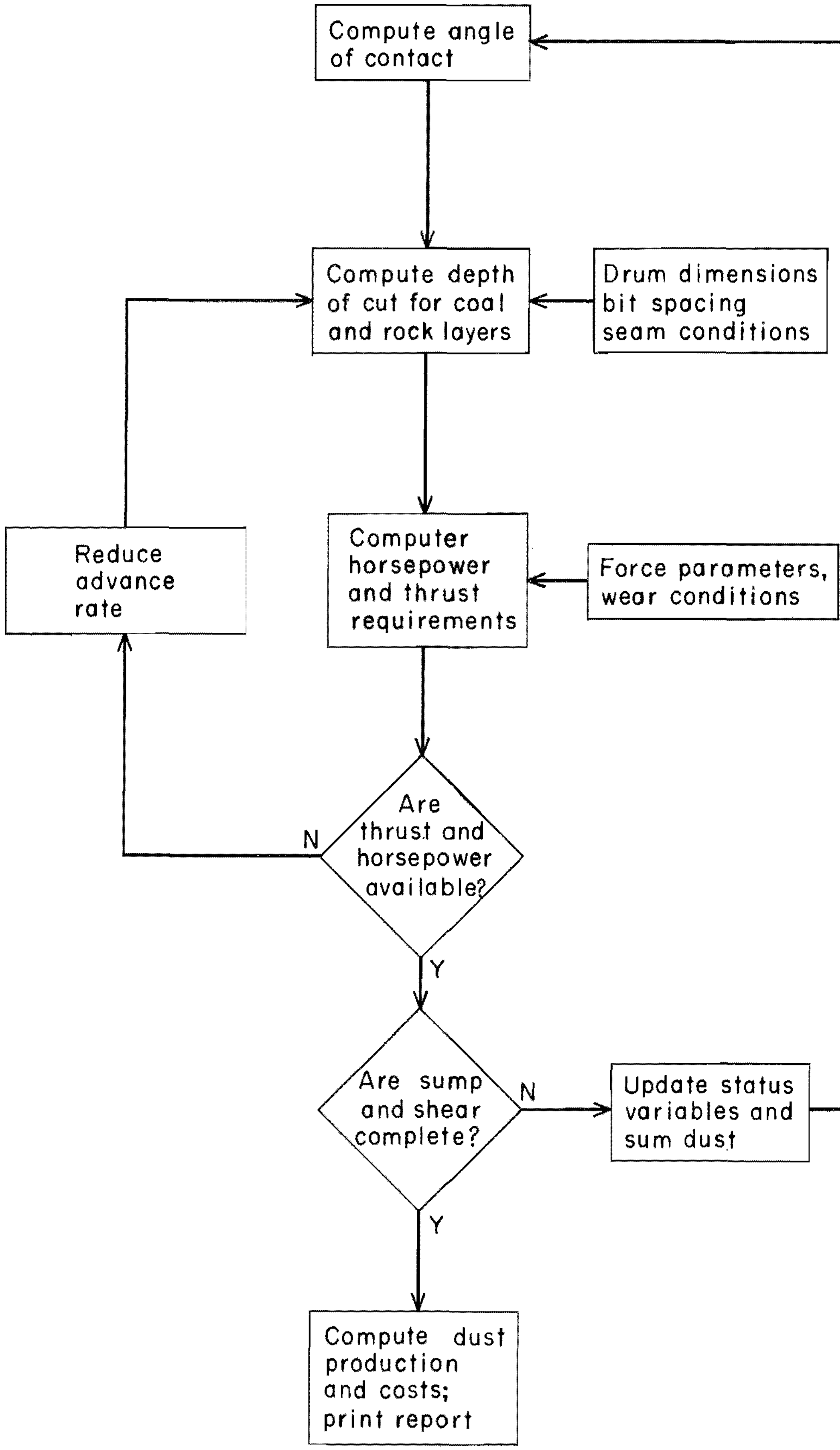

Figure 1.–Program flowchart.

program. The required torque is calculated from the cutting force, drum diameter, and number of bits. If this torque exceeds the available torque, the sump or shear rate is reduced by 5 pct of the original value and the calculation procedure is repeated. In a similar manner, the thrust required to advance the drum is calculated from the normal force and the number of bits. This iterative process is continued until the required torque or thrust is equal to or less than the available torque or thrust. Relative airborne dust, production, and cost values are calculated for a summary report. The program then returns the user to the main menu.

OPERATION

The program is menu driven. The main menu, which controls all the program functions, is shown in figure 2. Selecting item 1 on this menu causes the program to recalculate the relative dust value using the procedures described in the previous section. Figure 3 shows an example of the summary report that is generated by the analysis. At this point the user is given the option of printing a hard copy of the report. The user will be returned to the main menu regardless of the choice made.

Changes in parameter values are accomplished by selecting items 2 through 5 on the main menu. Figure 4 shows a change being made in the drum revolutions from 60 to 51 rpm. This menu was reached by selecting item 2 from the main menu. Appendix B gives a list of parameter definitions and identifies the category in which the parameter appears. Item 6 sets the wear condition of the bits. The value is entered as a percent of total bit life. Item 7 provides a data file utility that allows saving the current data file, inputting a new data file, or obtaining a hard copy of the entire data file. Item 8 provides online help messages to assist the user. Selecting this item causes

```
************************** MAIN MENU **************************

1 - RECALCULATE DUST VALUE  2 - MODIFY MACHINE PARAMETERS
3 - MODIFY SEAM PARAMETERS  4 - MODIFY OPERATOR-CONTROLLABLE PARAMETERS
5 - MODIFY BIT PARAMETERS   6 - CHANGE WEAR CONDITION
7 - DATA FILE UTILITY       8 - HELP MENU
9 - TERMINATE THIS RUN

        ENTER THE NUMBER FOR THE ACTION YOU WISH TO DO NEXT ?
```

Figure 2.–Main menu.

```
                    *** DUST ANALYSIS SUMMARY ***

AVG. CUT DEPTH (IN) - SUMP    2.00  AVG. CUT DEPTH (IN) - SHEAR       2.00
AVERAGE SUMP RATE (IN/SEC)    2.00  AVERAGE SHEAR RATE (IN/SEC)       2.00
BIT SPACING (IN)              1.50  BIT WEAR CONDITION (PCT)           0.0

SUMP
 AVAILABLE THRUST(LB)        33000  AVAILABLE DRUM TORQUE(FT-LB)     40000
 UTILIZED THRUST(LB)          4847  UTILIZED DRUM TORQUE(FT-LB)      19383

SHEAR
 AVAILABLE THRUST(LB)        74999  AVAILABLE DRUM TORQUE(FT-LB)     40000
 UTILIZED THRUST(LB)          2261  UTILIZED DRUM TORQUE(FT-LB)      14484

TONS/MINUTE                   7.60  TONS/SHIFT                         730
COST/TON - BITS AND POWER     0.33  COST/SHIFT - BITS AND POWER        241
PCT TOTAL DUST - SUMP         28.8  PCT TOTAL DUST - SHEAR            71.2

**************************************************************************
* FULL SHIFT RELATIVE DUST -    1569.50 PER TON     8.42 PER CU. M. *
**************************************************************************
```

Figure 3.–Sample summary report.

another menu, shown in figure 5, to be printed. The first seven items of the help index menu are identical to their counterparts on the main menu. Selecting the appropriate item from this menu will cause a help message covering the subject to be printed.

The program performs internal checks on the data as the calculations are being made. The user is informed if the bit spacing is less than 1 in and given the option to change the data before proceeding with the analysis. The value for the wear condition is checked to insure it is within the ranges specified by the input data. If the values for drum revolution per minute and sump rate result in a depth of cut greater than the drum radius, the user is so informed and returned to the main menu. Likewise, a similar check is made on the drum revolution per minute and the shear rate. These two checks are necessary to prevent an error condition which causes the program to terminate.

INPUT DATA

Most of the data required by the program is self-explanatory. Certain data elements need more explanation than is provided in appendix B. Data elements 3 through 5 are used to calculate the available downward force in the shear portion of the cut. The program assumes the hydraulic cylinders on the boom can exert enough force to raise the front end of the miner. If this is not the case, then the force they can exert must be calculated and entered as data element 3 and both data elements 4 and 5 must be set to 1.

The advancing thrust (data element 9) should be limited to the force available to advance the drum into the face. The force necessary to move the mass of the miner forward should not be included.

```
1  - DRUM DIAMETER (IN)                 44.5
2  - DRUM WIDTH (IN)                   124
3  - MACHINE WEIGHT (LB)             99999
4  - DRUM CENTER DISTANCE (IN)         144
5  - CENTER GRAVITY DISTANCE (IN)      108
6  - NUMBER OF SCROLLS                   1
7  - DRUM REVOLUTIONS (RPM)             60
8  - AVAIL. CUTTER TORQUE            40000
9  - AVAIL. ADVANCING THRUST         12000

       ENTER THE NUMBER OF THE VARIABLE YOU WISH
       TO CHANGE, USE ZERO(0) TO TERMINATE - 7
       ENTER NEW DRUM REVOLUTIONS (RPM) - 51

       ENTER THE NUMBER OF THE VARIABLE YOU WISH
       TO CHANGE, USE ZERO(0) TO TERMINATE - 0
```

Figure 4.–Parameter modification example.

```
###################    HELP INDEX FOR MAIN MENU    ###################

1 - RECALCULATE DUST VALUE  2 - MODIFY MACHINE PARAMETERS
3 - MODIFY SEAM PARAMETERS  4 - MODIFY OPERATOR-CONTROLLABLE PARAMETERS
5 - MODIFY BIT PARAMETERS   6 - CHANGE WEAR CONDITION
7 - DATA FILE UTILITY       8 - RETURN TO MAIN MENU

     ENTER THE NUMBER FOR THE ITEM FOR WHICH YOU DESIRE HELP ?
```

Figure 5.–Help index menu.

Since the CM-CSM provides the user with a relative dust value it should not be necessary to vary the two dust parameters (data elements 16 and 17). The values found in appendix C should be adequate for most analysis.

The maximum sump and shear rates should be set reasonably close (within 20 pct of the actual rates). As explained in the "Program Operation" section, the program will reduce these rates by 5 pct of the original value until calculations indicate the miner has sufficient thrust or torque to cut at that rate. If the initial value is very high compared with the actual value the program execution time is greatly increased and the final sump or shear rate could be significantly lower than the maximum possible.

The end ring parameters (data elements 25-27) are for one end of the drum only. The program assumes the drum has two ends in the computations.

The center chain section parameters (data elements 28-30) should be used for the chain mat on chain driven drums or for the strut sections for gear driven drums. The number of bits entered for a chain driven drum should be equal to that number that are found on a chain length equal to the drum circumference. The program assumes only one center section, so if a drum with two struts is being analyzed the data must include the number of bits on both struts even though there is a drum section between the struts.

The user must bear in mind the influence of production time per shift (data element 33) on the relative dust per cubic meter value. Generally, any parameter change that lowers production will lower relative dust per cubic meter if the production time per shift is unchanged. An example of this behavior is shown in table 1. The table shows an analysis of the effect of bit wear condition. In Case A, the production time per shift was fixed at 20 pct. Under these conditions the relative dust per short ton value increases with an increase in bit wear while relative dust per cubic meter begins decreasing after bit wear has reached 40 pct. In Case B, the production time was adjusted to produce a constant tonnage per shift. Dust per cubic meter, in this case, increases with increasing bit wear.

TABLE 1.–Effect of bit wear and production time on relative dust per cubic meter

Bit wear, pct	Dust, mg/st	Case A		Case B	
		St per shift	Dust, mg/m^3	Production time, pct	Dust, mg/m^3
0	598	900	9.88	20	9.88
10	628	865	10.00	20.8	10.39
20	729	754	10.10	23.8	12.02
30	796	687	10.06	26.2	13.17
40	866	631	10.06	28.5	14.34
50	931	570	9.76	31.5	15.37
60	1,012	519	9.66	34.6	16.72
70	1,041	497	9.52	36.2	17.23
80	1,100	467	9.46	38.5	18.20
90	1,121	449	9.27	40.0	18.53

Production time percent for Case A was 20.
Short ton per shift for Case B was 900.

VERIFICATION

The in-mine results from the Bureau contract "Deep Cutting Continuous Miner"[7] were compared with relative values calculated by the CM-CSM. The miner specifications are shown in table 2. The underground tests were run with 3 rpm (9, 18, and 51) and 3 depth of cuts (1, 2, and 3.5 in/r). The average sump and shear rates for each of the nine combinations of drum revolution per minute and depth of cut (advance per revolution) that were run are shown in table 3. These rates were input to the CM-CSM to calculate the relative dust value for each combination. The results are shown in table 4 and graphically in figure 6. The in-mine results showed a much larger amount of scatter than did the CM-CSM results. The in-mine data has a worst case coefficient of variation of 40 pct, but the nominal range is between 20 and 26 pct. This should be expected since the CM-CSM uses average values and is not subject to in-mine variations in ventilation, coal properties, and so forth. The in-mine data show a reduction of 63 pct between 51 rpm at 1-in depth and 9 rpm at 3.5 in depth while the CSM shows a 62 pct reduction for the same conditions. In the worst case, 51 rpm at 1-in depth for both in-mine and CSM the difference is only 25 pct. In spite of the in-mine scatter this is very good agreement.

TABLE 2.–Miner specifications

Variable	Value
Drum diameter .... in ..	44.5
Number of scrolls	1
Drum revolutions .... rpm ..	9,18,51
Seam height .... in ..	79
Sump distance .... in ..	18
Bits per scroll	20
Number of kerf lines–end	3
Number of kerf bits–end	9
End kerf section width	9
Number of bit lines–chain	12
Total number of bits–chain	12
Chain kerf section width .... in ..	24

[7]Black, S., and J. Rounds. Deep Cutting Continuous Miner. Effect of drum rotational speed and depth of cut on airborne respirable dust and specific energy (contract H0122039). BuMines OFR 154-77, 1977 286 pp.; NTIS PB 274345.

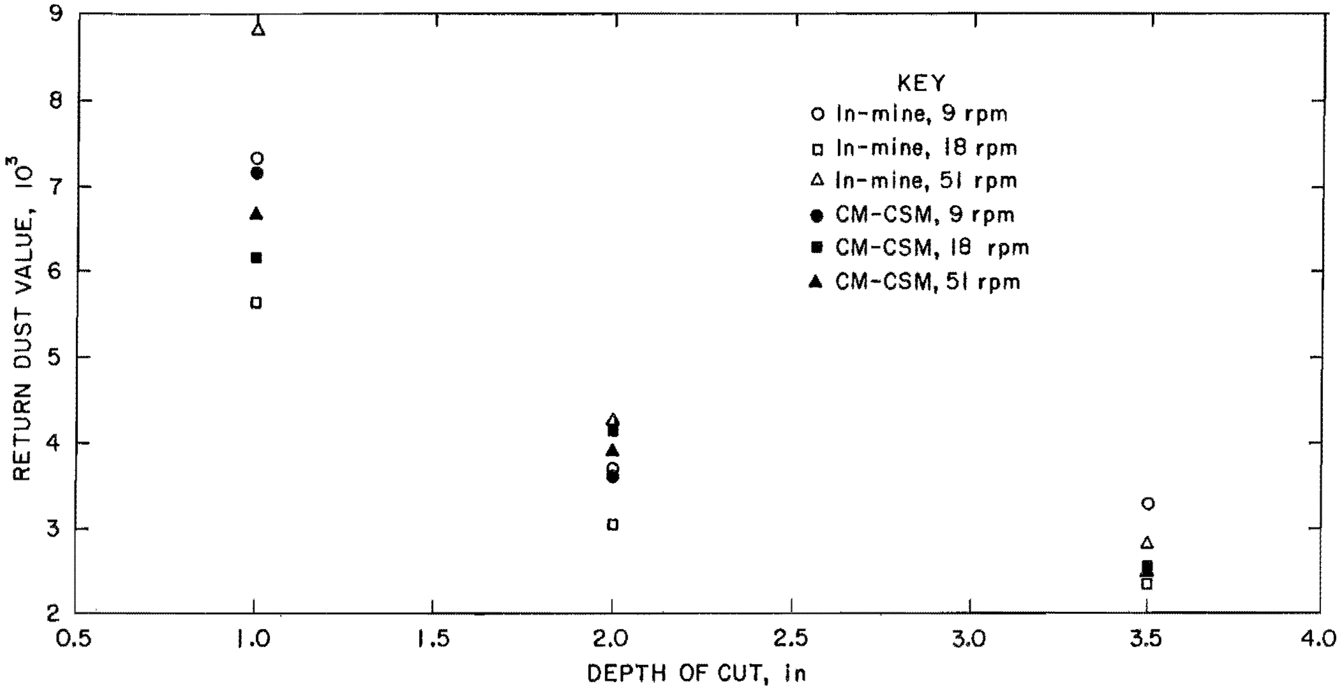

Figure 6.–Comparison of in-mine and CM-CSM dust results.

TABLE 3.–Average sump and shear rates from in-mine tests, inches per second

Advance . . . . in/r . .	1.0	2.0	3.5
9-rpm drum speed:			
Sump rate	0.10	0.28	0.49
Shear rate	.17	.35	.58
18-rpm drum speed:			
Sump rate	.27	.50	1.00
Shear rate	.35	.58	1.16
51-rpm drum speed:			
Sump rate	.79	1.42	2.73
Shear rate	.82	1.86	3.42

TABLE 4.–Comparison of in-mine and CM-CSM dust results, inches per second

Advance . . . in/r . .	1.0	2.0	3.5
9-rpm drum speed:			
In-mine	7,307	3,652	3,298
CM-CSM	7,183	3,645	2,521
18-rpm drum speed:			
In-mine	5,654	3,053	2,364
CM-CSM	6,177	4,127	2,539
51-rpm drum speed:			
In-mine	8,827	4,228	2,823
CM-CSM	6,653	3,874	2,526

SUMMARY

An interactive computer program has been developed which allows the user to evaluate, on a relative basis, the effect of cutting system changes on primary dust generation for continuous mining machines. The program is written in BASIC for use on IBM compatible microcomputers using MS-DOS. The program is menu driven and allows the user to systematically vary cutting system parameters either individually or collectively to determine their effect on dust generation.

The program can be used to determine the range of cutting parameters that produces the minimum relative dust value, thereby reducing or eliminating the need for extensive and costly underground testing. Those parameters, which have the greatest effect on dust, can be identified by using the program and given priority in any underground tests.

APPENDIX A.-PROGRAM LISTING

```
10 PRINT:PRINT:PRINT TAB(30);"CUTTING SYSTEM MODEL":PRINT
   TAB(26);"Continuous Miner Version 2.0"
20 PRINT TAB(34);"July 7, 1988"
30 PRINT:PRINT TAB(20);"by Bruce D. Hanson and Wallace W.
   Roepke":PRINT TAB(17);"US Department of the Interior, Bureau
   of Mines"
40 PRINT:PRINT TAB(10);" For technical assistance contact the
   authors at the Twin Cities"
50 PRINT TAB(10);" Research Center, 5629 Minnehaha Avenue So.,
   Minneapolis, MN 55417"
60 PRINT TAB(20);"or phone (612) 725-4782 or 725-4780"
70 PRINT:PRINT"  THIS PROGRAM CALCULATES RELATIVE RESPIRABLE DUST
   GENERATED BY A ROTARY DRUM"
80 PRINT"BASED ON THE DRUM DIMENSIONS, COAL PARAMETERS AND
   OPERATING CONDITIONS OF THE"
90 PRINT"MINER. SECONDARY DUST, THAT IS, DUST GENERATED BY THE
   GRINDING ACTION OF THE"
100 PRINT"DRUM AND FALLING COAL IS INCLUDED IN THE CALCULATIONS.
   THE EFFECT OF COLLECTION"
110 PRINT"AND/OR SUPPRESSION SYSTEMS ARE INCORPORATED IN THE
   PROGRAM. THE PROGRAM ALSO"
120 PRINT"CALCULATES BIT AND POWER COSTS FOR NEW AND WORN BITS.
   SITUATIONS WITH A ROCK"
130 PRINT"MIDDLEMAN CAN BE ANALYZED. THE USER CAN MODIFY ALL OF
   THE DRUM DIMENSIONS, COAL"
140 PRINT"PARAMETERS AND OPERATING CONDITIONS EITHER COLLECTIVELY
   OR INDIVIDUALLY TO"
150 PRINT"DETERMINE THE EFFECT ON DUST GENERATION."
160 PRINT:PRINT".....HIT ANY RETURN TO CONTINUE.....";:INPUT A$
170 PRINT:PRINT:PRINT:PRINT:PRINT:PRINT:PRINT TAB(30)"DISCLAIMER
   OF LIABILITY"
180 PRINT:PRINT:PRINT:PRINT"     The Bureau of Mines expressly
   declares that there are no warranties"
190 PRINT"express or implied which apply to the software
   contained herein. By acceptance"
200 PRINT"and use of said software, which is conveyed to the user
   without consideration"
210 PRINT"by the Bureau of Mines, the user hereof expressly
   waives any and all claims for"
220 PRINT"damage and/or suits for or by reason of personal
   injury, or property damage,"
230 PRINT"including special, consequential or similar damages
   arising out of or in any"
240 PRINT"way connected with the use of the software contained
   herein."
250 PRINT:PRINT:PRINT:PRINT
260 DIM NAM$(62),IV(62),PC(10),F$(1)
270 PI=3.1415926#:F$(0)="SCRN:":F$(1)="LPT1:"
280 DEF FN DC(Z)=R+A*COS(Z)-SQR(R*R-A*A*SIN(Z)^2)
290 PRINT:PRINT:PRINT TAB(10)"ENTER DATA FILE NAME ";:INPUT FI$
300 OPEN "I",#1,FI$
```

```
310 FOR I=1 TO 62:INPUT #1,NAM$(I),IV(I):NEXT I
320 CLOSE:GOTO 880
330 K=38:GOSUB 1310:MN=MF
340 K=51:GOSUB 1310
350 IF WC>IV(47) THEN PRINT:PRINT:PRINT:PRINT "You have specified
   a wear condition greater than";IV(47);" percent":PRINT: PRINT:
   GOTO 1050
360 OS=(IV(2)-IV(30)-2*IV(27))/IV(24)
370 B$="  Your bit spacing is less than 1 inch, this will lead to
   excessive dust levels. Do you still want the number of bits
   you have specified "
380 IF OS<1 THEN PRINT:PRINT:PRINT:PRINT B$;:INPUT A$:IF A$="N"
   THEN 880
390 A=60*IV(20)/IV(6)/IV(7):IF A<IV(1)/2 THEN 420
400 IV(20)=IV(1)*IV(6)*IV(7)/120
410 PRINT:PRINT TAB(15)"The depth of cut is greater than the drum
   radius, this causes the program to crash, please reduce the
   sump rate":GOTO 880
420 DSU=0:DSH=0:R=IV(1)/2:MA=IV(20):CA=IV(20)/20:HPSU=0:PRINT:
   PRINT:NR=0:GOSUB 1510
430 A=60*IV(21)/IV(6)/IV(7):IF A<IV(1)/2 THEN 460
440 IV(21)=IV(1)*IV(6)*IV(7)/120
450 PRINT:PRINT TAB(15)"The depth of cut is greater than the drum
   radius,this causes the program to crash, please reduce the
   shear rate ":GOTO 880
460 SS=TA/NR:CA=IV(21)/20:NS=0:USH=0:HPSH=0:SHHP=0:PRINT:PRINT:
   GOSUB 1800
470 TP=IV(22)*IV(10)*IV(2)*IV(7)/43200!/(NS+NR)
480 DSU=DSU*IV(19)/10*IV(1)/12*PI:DSH=DSH*IV(19)/10*IV(1)/12*PI
490 K=0
500 OPEN F$(K) FOR OUTPUT AS #1
510 PRINT#1," ":PRINT#1," ":PRINT#1,TAB(21)"*** DUST ANALYSIS
   SUMMARY ***":PRINT#1," "
520 A$="_A_V_G_._ _C_U_T_ _D_E_P_T_H_ _(_I_N_)_ _-_ _S_U_M_P_ _ _
   ####.##" :PRINT#1,USING A$;SS;
530 A$="_A_V_G_._ _C_U_T_ _D_E_P_T_H_ _(_I_N_)_ _-_ _S_H_E_A_R_ _
   ####.##"
540 SH=(TS-IV(1))/NS:PRINT#1, TAB(40);:PRINT#1,USING A$;SH
550 A$="_A_V_E_R_A_G_E_ _S_U_M_P_ _R_A_T_E_ _(_I_N_/_S_E_C_)_ _ _
   ####.##":PRINT#1,USING A$;SS*IV(7)/60;
560 A$="_A_V_E_R_A_G_E_ _S_H_E_A_R_ _R_A_T_E_ _(_I_N_/_S_E_C_)_ _
   ####.##":PRINT#1,TAB(40);:PRINT#1,USING A$;SH*IV(7)/60
570 OS=(IV(2)-IV(30)-2*IV(27))/IV(24)
580 A$="_B_I_T_ _S_P_A_C_I_N_G_ _(_I_N_)_ _ _ _ _ _ _ _ _ _ _ _ _
   ####.##":PRINT#1,USING A$;OS;
590 A$="_B_I_T_ _W_E_A_R_ _C_O_N_D_I_T_I_O_N_ _(_P_C_T_)_ _ _ _ _
   #####.#":PRINT#1,TAB(40);:PRINT#1,USING A$;WC:PRINT#1," ":
   PRINT#1,"SUMP"
600 A$="_ _ _A_V_A_I_L_A_B_L_E_ _T_H_R_U_S_T_(_L_B_)_ _ _ _ _ _
   ########":AST=IV(9) :PRINT#1,USING A$;AST;
610 A$="_A_V_A_I_L_A_B_L_E_ _D_R_U_M_ _T_O_R_Q_U_E_(_F_T_-_L_B_)_
   #######":PRINT#1,TAB(40);:PRINT#1,USING A$;IV(8)
620 A$="_ _ _U_T_I_L_I_Z_E_D_ _T_H_R_U_S_T_(_L_B_)_ _ _ _ _ _ _ _
   #######":PRINT#1,USING A$;UST;
```

```
630 A$="_U_T_I_L_I_Z_E_D_ _D_R_U_M_ _T_O_R_Q_U_E_(_F_T_-_L_B_)_ _
   #######":PRINT#1,TAB(40);:PRINT#1,USING A$;SUHP:PRINT#1," ":
   PRINT#1,"SHEAR"
640 A$="_ _ _A_V_A_I_L_A_B_L_E_ _T_H_R_U_S_T_(_L_B_)_ _ _ _ _ _ _ _
   #######":PRINT#1,USING A$;AN;
650 A$="_A_V_A_I_L_A_B_L_E_ _D_R_U_M_ _T_O_R_Q_U_E_(_F_T_-_L_B_)_
   #######":PRINT#1,TAB(40);:PRINT#1,USING A$;IV(8)
660 A$="_ _ _U_T_I_L_I_Z_E_D_ _T_H_R_U_S_T_(_L_B_)_ _ _ _ _ _ _ _
   #######":PRINT#1,USING A$;USH;
670 A$="_U_T_I_L_I_Z_E_D_ _D_R_U_M_ _T_O_R_Q_U_E_(_F_T_-_L_B_)_ _
   #######":PRINT#1,TAB(40);:PRINT#1,USING A$;SHHP:PRINT#1," "
680 A$="_T_O_N_S_/_M_I_N_U_T_E_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
   ####.##":PRINT#1,USING A$;TP;
690 A$="_T_O_N_S_/_S_H_I_F_T_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
   #######":PS=TP*IV(33)*4.8:PRINT#1, TAB(40);:
   PRINT#1,USING A$;PS
700 GOSUB 2560
710 A$="_C_O_S_T_/_T_O_N_ _-_ _B_I_T_S_ _A_N_D_ _P_O_W_E_R_ _ _ _
   ####.##":PRINT#1,USING A$;CT;
720 A$="_C_O_S_T_/_S_H_I_F_T_ _-_ _B_I_T_S_ _A_N_D_ _P_O_W_E_R_ _
   #######":PRINT#1,TAB(40);:PRINT#1,USING A$;PS*CT
730 DU=DSU+DSH:SUC=100*DSU/DU:SHC=100-SUC
740 A$="_P_C_T_ _T_O_T_A_L_ _D_U_S_T_ _-_ _S_U_M_P_ _ _ _ _ _ _ _
   #####.#":PRINT#1,USING A$;SUC;
750 A$="_P_C_T_ _T_O_T_A_L_ _D_U_S_T_ _-_ _S_H_E_A_R_ _ _ _ _ _ _
   #####.#":PRINT#1, TAB(40);:PRINT#1,USING A$;SHC
760 DM=DU*IV(7)/(NR+NS)/7.7E+08*(100-IV(32))/100:
   DS=35.3145*DM/IV(31)*IV(33)/100
770 PRINT#1,"":PRINT#1,TAB( 3);"********************************
   ***************************************"
780 A$="*_ _F_U_L_L_ _S_H_I_F_T_ _R_E_L_A_T_I_V_E_ _D_U_S_T_ _-_
   #######.##_ _P_E_R_ _T_O_N
   #######.##_ _P_E_R_ _C_U_._ _M_._ _*"
790 PRINT#1,TAB(3);:PRINT#1,USING A$;DM/TP;DS
800 PRINT#1,TAB(3);"*********************************************
   *************************"
810 PRINT#1,"":CLOSE
820 IF K>0 THEN 880
830 PRINT TAB(18)"DO YOU WISH A HARD COPY (Y/N) ";
840 INPUT A$:IF A$="Y" THEN 870
850 IF A$="N" THEN 880
860 GOTO 830
870 K=1:GOTO 500
880 OB=0:MA=0
890 PRINT:PRINT"****************************** MAIN MENU *******
   ***********************"
900 PRINT:PRINT "1 - RECALCULATE DUST VALUE";:PRINT TAB(35)
   "2 - MODIFY MACHINE PARAMETERS"
910 PRINT "3 - MODIFY SEAM PARAMETERS";:PRINT TAB(35)
   "4 - MODIFY OPERATOR-CONTROLLABLE PARAMETERS"
920 PRINT "5 - MODIFY BIT PARAMETERS";:PRINT TAB(35)
   "6 - CHANGE WEAR CONDITION"
930 PRINT "7 - DATA FILE UTILITY";:PRINT TAB(35)"8 - HELP
   INDEX":PRINT "9 - TERMINATE THIS RUN"
```

```
940 PRINT:PRINT TAB(9)"ENTER THE NUMBER FOR THE ACTION YOU WISH
   TO DO NEXT ";:INPUT WT
950 IF WT<1 OR WT>9 THEN 890
960 ON WT GOTO 330,970,980,1040,990,1050,1060,1070,1080
970 N1=1:N2=9:GOSUB 1160:GOTO 890
980 N1=10:N2=19:GOSUB 1160:GOTO 890
990 N1=37:N2=49:PRINT:PRINT TAB(9)"DO YOU WISH TO MODIFY NORMAL
   (N) OR CUTTING (C) FORCE PARAMETERS ";
1000 A=0:INPUT A$:IF A$="N" THEN 1030
1010 IF A$="C" THEN A=13:GOTO 1030
1020 GOTO 990
1030 N1=N1+A:N2=N2+A:GOSUB 1160:GOTO 890
1040 N1=20:N2=36:GOSUB 1160:GOTO 890
1050 PRINT:PRINT TAB(18)"ENTER WEAR CONDITION (%) - ";:
   INPUT WC:GOTO 890
1060 GOSUB 2440:GOTO 890
1070 GOSUB 2610:GOTO 890
1080 PRINT:PRINT TAB(9)"ARE YOU SURE YOU WISH TO TERMINATE THE
   PROGRAM (Y/N) ";:INPUT A$
1090 IF A$="N" THEN 890
1100 IF A$="Y" THEN END
1110 GOTO 890
1120 END
1130 REM
1140 REM VARIABLE CHANGE ROUTINE
1150 REM
1160 N=0:PRINT:PRINT
1170 FOR I=N1 TO N2:X=35-LEN(NAM$(I))-INT(I/10):PRINT TAB(18)I;
   " - ";NAM$(I); SPC( X);IV(I):NEXT I
1180 PRINT:PRINT TAB(18)"ENTER THE NUMBER OF THE VARIABLE YOU
   WISH ":PRINT TAB(18)"TO CHANGE, USE ZERO(0) TO TERMINATE ";
1190 INPUT "- ";J:IF J=0 THEN 1210
1200 N=N+1:PC(N)=J:PRINT TAB(18)"ENTER NEW ";NAM$(J);:INPUT
   " - ";IV(J):GOTO 1180
1210 IF N=0 THEN RETURN
1220 PRINT:PRINT TAB(18)"DO YOU WISH A HARD COPY OF THESE CHANGES
   (Y/N) ";:INPUT A$:IF A$="Y" THEN 1250
1230 IF A$="N" THEN RETURN
1240 GOTO 1220
1250 OPEN F$(1) FOR OUTPUT AS #1
1260 PRINT#1," "
1270 FOR K=1 TO N:L=PC(K):PRINT#1,TAB(9)"******** ";NAM$(L);
   " - ";IV(L):NEXT K:PRINT#1," ":CLOSE:RETURN
1280 REM
1290 REM   WEAR MULTIPLIER ROUTINE
1300 REM
1310 FOR I=1 TO 3:K=K+3:IF WC<=IV(K) THEN 1330
1320 NEXT I
1330 MF=IV(K+1)+WC*IV(K+2):RETURN
1340 REM
1350 REM  CUT DEPTH ROUTINE
1360 REM
1370 SM=FN DC(P1):IF SM>DX THEN SM=DX
1380 IF F=1 THEN SM=SM*COS(P1)
```

```
1390 DL=FN DC(P2):IF DL>DX THEN DL=DX
1400 IF F=1 THEN DL=DL*COS(P2)
1410 SM=SM+DL:DL=(P2-P1)/10
1420 FOR I=2 TO 8 STEP 2:X=FN DC(I*DL+P1):IF X>DX THEN X=DX
1430 IF F=1 THEN X=X*COS(I*DL+P1)
1440 SM=SM+2*X:NEXT I
1450 FOR I=1 TO 9 STEP 2:X=FN DC(I*DL+P1):IF X>DX THEN X=DX
1460 IF F=1 THEN X=X*COS(I*DL+P1)
1470 SM=SM+4*X:NEXT I:SM=SM/30:RETURN
1480 REM
1490 REM SUMP ROUTINE
1500 REM
1510 TA=0
1520 OS=(IV(2)-IV(30)-2*IV(27))/IV(24):A=60*MA/IV(7)/IV(6):
   DX=OS*TAN((90-IV(14)/2)*PI/180)
1530 P2=ATN(A/2/SQR(R*R-A*A/4))+PI/2:P3=-P2:
   IF TA<R THEN P3=-ATN(SQR(2*R*TA-TA*TA)/(R-TA))
1540 MT=IV(11):MB=IV(12):CH=R+SQR(2*R*TA-TA*TA):P1=P3:
   NB=IV(6)*IV(24):GOSUB 2190
1550 TN=NF:TC=FC:TD=D
1560 REM
1570 REM          END RING
1580 REM
1590 A=A*IV(25)/IV(26):P2=ATN(A/2/SQR(R*R-A*A/4))+PI/2:P3=-P2:
   IF TA<R THEN P3=-ATN(SQR(2*R*TA-TA*TA)/(R-TA))
1600 P1=P3:OS=IV(27)/IV(25):DX=OS*TAN((90-IV(14)/2)*PI/180):
   NB=2*IV(26):GOSUB 2190
1610 TN=TN+NF:TC=TC+FC:TD=TD+D
1620 REM
1630 REM        CENTER SECTION
1640 REM
1650 A=A*IV(26)/IV(25)*IV(28)/IV(29):
   P2=ATN(A/2/SQR(R*R-A*A/4))+PI/2:P3=-P2:
   IF TA<R THEN P3=-ATN(SQR(2*R*TA-TA*TA)/(R-TA))
1660 P1=P3:OS=IV(30)/IV(28):DX=OS*TAN((90-IV(14)/2)*PI/180):
   NB=IV(29):GOSUB 2190
1670 TN=TN+NF:TC=TC+FC:TD=TD+D
1680 IF IV(9)>TN THEN UST=TN:GOTO 1700
1690 MA=MA-CA:GOTO 1520
1700 AC=IV(1)*TC/12
1710 IF IV(8)>AC THEN 1730
1720 MA=MA-CA:GOTO 1520
1730 TA=TA+60*MA/IV(7)/IV(6):NR=NR+1:DSU=DSU+TD:SUHP=AC:
   HPSU=HPSU+IV(7)/2/5260*AC+5*MA*TN/33000!
1740 LOCATE 23,1:PRINT USING "_ _ _ _ _ _ _ _ _ _ _T_H_E_
   _M_I_N_E_R_ _H_A_S_ _C_O_M_P_L_E_T_E_D###.#_ _I_N_C_H_E_S_
   _O_F_ _S_U_M_P";TA
1750 IF TA<IV(22) THEN 1520
1760 LSU=A:RETURN
1770 REM
1780 REM          SHEAR ROUTINE
1790 REM
1800 TS=IV(1):CH=IV(22)
1810 MA=IV(21):IF TS<IV(11) THEN XYZ=1:GOTO 1880
```

```
1820 IF TS>IV(12) THEN  1850
1830 IF (TS-R)<IV(11) THEN XYZ=2:
   MT=R-SQR(R^2-(R+IV(11)-TS)^2):MB=CH:GOTO 1880
1840 XYZ=3:MB=CH:GOTO 1880
1850 IF (TS-R)<IV(11) THEN XYZ=4:MT=R-SQR(R^2-(R+IV(11)-TS)^2):
   MB=R-SQR((R^2)-(R+IV(12)-TS)^2):GOTO 1880
1860 IF (TS-R)<IV(12) THEN XYZ=5:
   MB=R-SQR((R^2)-(R+IV(12)-TS)^2):GOTO 1880
1870 XYZ=1
1880 OS=(IV(2)-IV(30)-2*IV(27))/IV(24):NB=IV(6)*IV(24):
   A=60*MA/IV(7)/IV(6):DX=OS*TAN((90-IV(14)/2)*PI/180)
1890 NF=0:FC=0:D=0:P1=ATN((R-CH)/SQR(CH*(2*R-CH))):
   P2=ATN(A/2/SQR(R*R-A*A/4))+PI/2:P3=P1
1900 ON XYZ GOSUB 2400,2190,2320,2190,2310
1910 TN=NF:TC=FC:TD=D
1920 REM
1930 REM                   END RING
1940 REM
1950 OS=IV(27)/IV(25):DX=OS*TAN((90-IV(14)/2)*PI/180):
   A=A*IV(25)/IV(26):NB=2*IV(26):NF=0:FC=0:D=0
1960 P1=ATN((R-CH)/SQR(CH*(2*R-CH))):
P2=ATN(A/2/SQR(R*R-A*A/4))+PI/2:P3=P1
1970 ON XYZ GOSUB 2400,2190,2320,2190,2310
1980 TN=TN+NF:TC=TC+FC:TD=TD+D
1990 REM
2000 REM                   CENTER SECTION
2010 REM
2020 OS=IV(30)/IV(28):DX=OS*TAN((90-IV(14)/2)*PI/180):
   A=A*IV(26)/IV(25)*IV(28)/IV(29):NB=IV(29):NF=0:FC=0:D=0
2030 P1=ATN((R-CH)/SQR(CH*(2*R-CH))):
   P2=ATN(A/2/SQR(R*R-A*A/4))+PI/2:P3=P1
2040 ON XYZ GOSUB 2400,2190,2320,2190,2310
2050 TN=TN+NF:TC=TC+FC:TD=TD+D
2060 AN=IV(3)*IV(5)/IV(4):IF AN>TN THEN 2080
2070 MA=MA-CA:GOTO 1880
2080 AC=IV(1)*TC/12:IF IV(8)>AC THEN 2100
2090 MA=MA-CA:GOTO 1880
2100 TS=TS+60*MA/IV(7)/IV(6):NS=NS+1:DSH=DSH+TD:
   HPSH=HPSH+AC*IV(7)/2/5260
2110 IF USH<TN THEN USH=TN
2120 IF SHHP<AC THEN SHHP=AC
2130 LOCATE 23,1:PRINT USING "_ _ _ _ _ _ _ _ _ _T_H_E_
   _M_I_N_E_R_ _H_A_S###.#_ _I_N_C_H_E_S_ _O_F_ _S_H_E_A_R_
   _R_E_M_A_I_N_I_N_G";IV(10)-TS;
2140 IF TS<IV(10) THEN 1810
2150 RETURN
2160 REM
2170 REM                   DUST/FORCE ROUTINE
2180 REM
2190 NF=0:FC=0:D=0:IF MT=MB OR MT=>CH THEN 2400
2200 REM
2210 REM              CALCULATE DUST & FORCES FOR TOP COAL
2220 REM
2230 X=(IV(1)-2*MT)/IV(1):P1=ATN(X/SQR(1-X*X)):F=1:GOSUB 1370
```

```
2240 NF=MN*(IV(37)*(SIN(P2)-SIN(P1))/(P2-P1)+IV(38)*SM)*(P2-P1)
   /PI/2*NB
2250 F=0:GOSUB 1370:D=(IV(16)+SM*IV(17))*NB*((P2-P1)/PI/2)
2260 FC=MF*(IV(50)+SM*IV(51))*(P2-P1)/PI/2*NB
2270 REM
2280 REM              CALCULATE DUST & FORCES FOR MIDDLEMAN
2290 REM
2300 P2=P1:P1=P3:IF MB=>CH THEN 2320
2310 X=(IV(1)-2*MB)/IV(1):P1=ATN(X/SQR(1-X*X))
2320 F=1:GOSUB 1370:NF=NF+MN*(IV(39)*(SIN(P2)-SIN(P1))/
   (P2-P1)+IV(40)*SM)*(P2-P1)/PI/2*NB
2330 F=0:GOSUB 1370:FC=FC+MF*(IV(52)+IV(53)*SM)*(P2-P1)/PI/2*NB
2340 D=D+(IV(16)+SM*IV(17))*NB*((P2-P1)/PI/2)*(5^(IV(13)*.01))*2
2350 IF MB=>CH THEN RETURN
2360 REM
2370 REM              CALCULATE BOTTOM COAL DUST & FORCES
2380 REM
2390 P2=P1:P1=P3
2400 F=1:GOSUB 1370:NF=NF+MN*(IV(37)*(SIN(P2)-SIN(P1))/
   (P2-P1)+IV(38)*SM)*(P2-P1)/PI/2*NB
2410 F=0:GOSUB 1370:D=D+(IV(16)+SM*IV(17))*NB*((P2-P1)/PI/2)
2420 FC=FC+MF*(IV(50)+SM*IV(51))*(P2-P1)/PI/2*NB
2430 RETURN
2440 PRINT:PRINT:PRINT"###############################  DATA FILE
   UTILITY ############################"
2450 PRINT:PRINT"1 - SAVE CURRENT DATA FILE";:PRINT TAB(40)"2 -
   PRINT CURRENT DATA FILE"
2460 PRINT"3 - READ NEW DATA FILE";:PRINT TAB(40)"4 - RETURN TO
   MAIN MENU"
2470 PRINT:PRINT TAB(9)"ENTER THE NUMBER FOR THE ACTION YOU WISH
   TO DO NEXT ";:INPUT WT
2480 ON WT GOTO 2490,2530,2510,2550
2490 PRINT:INPUT;"ENTER SAVE DATA FILE NAME ";FI$:PRINT:
   OPEN "O", #2, FI$
2500 FOR I=1 TO 62:PRINT #2, NAM$(I);",";IV(I):NEXT I:
   CLOSE 2:GOTO 2440
2510 PRINT:PRINT TAB(9)"ENTER NEW DATA FILE NAME ";:
   INPUT FI$:OPEN "I", #1, FI$
2520 FOR I=1 TO 62:INPUT #1, NAM$(I), IV(I):NEXT I:CLOSE:
   GOTO 2440
2530 OPEN "O", #1, "LPT1:":
   A$="#####_ _ _ \                                       \"
2540 FOR I=1 TO 62:PRINT#1,USING A$; I,NAM$(I);:PRINT#1,IV(I):
   NEXT I:CLOSE 1:GOTO 2440
2550 RETURN
2560 KW=.746*(HPSU/NR+HPSH/NS):KH=KW*IV(33)*8/100:BL=IV(36)
2570 IF IV(12)-IV(11)=0 THEN 2600
2580 IF IV(12)-IV(11)>0 THEN 2590
2590 BL=IV(36)/SQR(IV(22)-IV(21))/SQR(4.3^(IV(23)*.01)
   -.02*IV(23))
2600 CT=IV(34)/BL+KH*IV(35)/PS:RETURN
2610 REM HELP MENU
2620 PRINT:PRINT:PRINT"##########################  HELP INDEX FOR
   MAIN MENU ########################"
```

```
2630 PRINT:PRINT"1 - RECALCULATE DUST VALUE";:PRINT TAB(35)
   "2 - MODIFY MACHINE PARAMETERS"
2640 PRINT"3 - MODIFY SEAM PARAMETERS";:PRINT TAB(35)
   "4 - MODIFY OPERATOR-CONTROLLABLE PARAMETERS"
2650 PRINT"5 - MODIFY BIT PARAMETERS";:PRINT TAB(35)"6 - CHANGE
   WEAR CONDITION"
2660 PRINT"7 - DATA FILE UTILITY";:PRINT TAB(35)"8 - RETURN TO
   MAIN MENU"
2670 PRINT:PRINT TAB(9)"ENTER THE NUMBER FOR THE ITEM FOR WHICH
   YOU DESIRE HELP ";:INPUT HT
2680 IF HT<1 OR HT>8 THEN 2620
2690 ON HT GOTO 2700, 2790, 2840, 2910, 2960, 3010, 3070, 3110
2700 PRINT:PRINT:PRINT"****************** MENU 1 - RECALCULATE
   RELATIVE DUST VALUE ******************"
2710 PRINT" THIS MENU ITEM WILL CAUSE THE PROGRAM TO CALCULATE
   THE RELATIVE DUST VALUE"
2720 PRINT"BASED ON THE CURRENT PARAMETER VALUES AND THE
   SPECIFIED SUMP AND SHEAR RATES."
2730 PRINT"THE USER MAY PRINT A HARD COPY OF THE SUMMARY REPORT
   WHEN THE CALCULATIONS ARE"
2740 PRINT"COMPLETE. THE PROGRESS OF THE DRUM IN THE SUMP AND
   SHEAR CUTS IS SHOWN ON THE"
2750 PRINT"SCREEN. IF THE AVAILABLE HORSEPOWER OR THRUST IS
   INSUFFICENT TO ADVANCE THE"
2760 PRINT"MACHINE AT THE SPECIFIED RATE THE PROGRAM WILL
   DECREASE THE SUMP OR SHEAR RATE"
2770 PRINT"UNTIL THE REQUIRED HORSEPOWER OR THRUST IS LESS THAN
   THE AVAILABLE."
2780 PRINT"**************************************************
   ****************************":GOTO 2620
2790 PRINT:PRINT:PRINT"****************** MENU ITEM 2 - MODIFY
   MACHINE PARAMETERS *******************"
2800 PRINT"THE USER CAN CHANGE ANY OF THE 9 VARIABLES WHICH
   DESCRIBE THE CONTINUOUS"
2810 PRINT"MINER. THE PROGRAM HAS NO INTERNAL ERROR CHECKING
   ROUTINES TO INSURE THAT THE"
2820 PRINT"DRUM DIMENSIONS ARE CONSISTENT WITH EACH OTHER."
2830 PRINT"****************************************************
   **************************":GOTO 2620
2840 PRINT:PRINT:PRINT"******************** MENU ITEM 3 - MODIFY
   SEAM PARAMETERS ********************"
2850 PRINT"THE USER CAN CHANGE ANY OF 10 SEAM AND/OR COAL
   PROPERTY VARIABLES. THE ROCK"
2860 PRINT"BAND VALUES (TOP AND BOTTOM) ARE MEASURED FROM THE TOP
   OF THE MINING HORIZON."
2870 PRINT"ONE ASPECT OF PROGRAM FLOW IS CONTROLLED BY VARIABLES
   IN THIS MENU. SETTING THE"
2880 PRINT"ROCK BAND TOP EQUAL TO THE ROCK BOTTOM WILL CAUSE THE
   PROGRAM TO CONSIDER"
2890 PRINT"CUTTING ONLY COAL."
2900 PRINT"****************************************************
   **************************":GOTO 2620
2910 PRINT:PRINT:PRINT"*********** MENU ITEM 4 - MODIFY OPERATOR
   - CONTROLLABLE PARAMETERS ************"
```

```
2920 PRINT"THIS MENU ALLOWS THE USER TO CHANGE 17 'CONTROLLABLE'
   PARAMETERS SUCH AS AIR"
2930 PRINT"FLOW, PRODUCTION TIME PER SHIFT, NUMBER OF BITS, BIT
   LIFE, COST OF BITS, COST OF"
2940 PRINT"POWER, AND DUST SUPPRESSION ETC."
2950 PRINT"******************************************************
   ***************************":GOTO 2620
2960 PRINT:PRINT:PRINT"********************* MENU ITEM 5 - MODIFY
   BIT PARAMETERS **********************"
2970 PRINT"THE USER CAN CHANGE ANY OF 26 FORCE AND WEAR
   CHARACTERISTICS OF THE BITS"
2980 PRINT"BEING USED IN THE ANALYSIS. THE VALUES FOR FORCE AND
   WEAR PARAMETERS MUST BE"
2990 PRINT"OBTAINED FROM IN SITU FORCE MEASUREMENTS AND FROM LAB
   WEAR TESTS."
3000 PRINT"******************************************************
   ***************************":GOTO 2620
3010 PRINT:PRINT:PRINT"********************* MENU ITEM 6 - CHANGE
   WEAR CONDITION **********************"
3020 PRINT" THE USER CAN CHANGE THE WEAR CONDITION OF BITS
   THROUGH THIS MENU ITEM. THE"
3030 PRINT"WEAR CONDITION IS EXPRESSED IN A PERCENTAGE, ZERO (0)
   BEING A NEW BIT, AND 100"
3040 PRINT"REPRESENTING A TOTALLY WORN BIT. THE WEAR CONDITION IS
   USED TO DETERMINE A FORCE"
3050 PRINT"MULTIPLIER FOR THE BITS."
3060 PRINT"******************************************************
   ***************************":GOTO 2620
3070 PRINT:PRINT:PRINT"************************ MENU ITEM 7 -
   DATA FILE UTILITY ***********************"
3080 PRINT"THIS OPTION ALLOWS THE USER TO SAVE THE CURRENT DATA
   FILE , READ A NEW DATA,"
3090 PRINT"OR OBTAIN A PRINTER LISTING OF DATA FILE VALUES."
3100 PRINT"******************************************************
   ***************************":GOTO 2620
3110 RETURN
```

APPENDIX B.–PARAMETER DEFINITION

Element Number	Name - Description
	MACHINE PARAMETERS
1	DRUM DIAMETER (IN) - Bit tip to bit tip diameter
2	DRUM WIDTH (IN) - Cutting width of the drum
3	MACHINE WEIGHT (LB) - Weight of the mining machine. If the hydraulic cylinders on the boom cannot lift the front end of the machine off the floor then the maximum force the cylinders can exert should be used
4	DRUM CENTER DISTANCE (IN) - The distance from stabilizing jack (rear sprocket of tracks, if miner has no stabilizing jack) to the center of drum at the midpoint of the shear cut
5	CENTER GRAVITY DISTANCE (IN) - The distance from the stabilizing jack to the center of gravity of the miner
6	NUMBER OF SCROLLS - number of scrolls on the main portion of the drum
7	DRUM REVOLUTIONS (RPM) - Drum speed as measured in RPM
8	AVAIL. CUTTING TORQUE - Torque available to turn the drum
9	AVAIL. ADVANCING THRUST - Thrust available to sump the miner into the face
	SEAM PARAMETERS
10	SEAM HEIGHT (IN) - Height of coal and rock being removed
11	ROCK BAND TOP (IN) - Distance from the top of the seam to the top of the rock band
12	ROCK BAND BOTTOM (IN) - Distance from the top of the seam to the bottom of the rock band, if set equal to the ROCK BAND TOP the program assumes there is no rock band
13	PCT SILICA IN ROCK BAND - Percent silica in the rock band
14	BREAKOUT ANGLE (^{0}) - A measure of the bit interaction, the included angle of the trench left by the bit. This angle will vary for different coal type, and bedding plane direction.
15	SWELL FACTOR - Ratio of mined volume to insitu volume
16	FIRST DUST PARAMETER - Intercept of the linear dust versus cut depth equation
17	SECOND DUST PARAMETER - Slope of the linear dust versus cut depth equation
18	COMPRESSIVE STRENGTH - Compressive strength measured in pounds per square inch. (Not currently used, reserved for future modifications)
19	GRINDABILITY INDEX - Hardgrove Grindability Index

	OPERATOR CONTROLLABLE PARAMETERS
20	MAX. SUMP RATE (IN/S) - The maximum rate at which the miner will attempt to sump into the face
21	MAX. SHEAR RATE (IN/S) - The maximum rate at which the miner will attempt to shear down
22	SUMP DISTANCE (IN) - The distance the miner sumps into the face during the sump portion of the cycle
23	ENTRY WIDTH (IN) - Width of the entry being mined
24	BITS PER SCROLL - The number of bits on one scroll of the main potion of the drum
25	NUMBER OF KERF LINES--END - Number of kerf lines on the drum end
26	NUMBER OF KERF BITS--END - Number of kerf bits on the drum end
27	END KERF SECTION WIDTH - Width of the kerf cutter section on the end of the drum
28	NUMBER OF KERF LINES--CHAIN - Total number of kerf lines on the chain or strut sections of the drum
29	NUMBER OF KERF BITS--CHAIN - Total number of kerf bits on the chain or strut sections of the drum
30	CENTER CHAIN SECTION WIDTH (IN) - Width of the center chain or strut section(s) on the drum
31	AIRFLOW (CFM) - Average airflow at the middle of the face, measured in cubic feet per minute
32	DUST SUPPRESSION (PCT) - Percent reduction in the total dust value to due suppression system
33	PRODUCTION TIME PER SHIFT (PCT) - Percent of shift spent cutting coal, based on an 8-hour shift
34	COST PER KILOWATT-HOUR - Cost per kilowatt-hour at the face
35	COST PER BIT - Cost of bit installed on drum
36	BIT LIFE (ST) - Average bit life, expressed in tons

	BIT NORMAL FORCE PARAMETERS *
37	NORMAL FORCE INTERCEPT - Intercept for the normal force versus cut depth equation, cutting in coal
38	NORMAL FORCE SLOPE - Slope for the normal force versus cut depth equation, cutting in coal
39	RB NORMAL FORCE INTERCEPT - Intercept for the normal force versus cut depth equation, cutting in rock
40	RB NORMAL FORCE SLOPE - Slope for the normal force versus cut depth equation, cutting in rock
41	FIRST STAGE END POINT (PCT) - Defines the end of the first straight line segment of the wear function for normal force
42	FIRST STAGE INTERCEPT - Intercept of the first straight line segment
43	FIRST STAGE SLOPE - Slope of the first straight line segment
44	SECOND STAGE END POINT (PCT) - Defines the end of the second straight line segment of the wear function for normal force
45	SECOND STAGE INTERCEPT - Intercept of the second straight line segment

46	SECOND STAGE SLOPE - Slope of the second straight line segment
47	THIRD STAGE END POINT (PCT) Defines the end of the third straight line segment of the wear function for normal force
48	THIRD STAGE INTERCEPT - Intercept of the third straight line segment
49	THIRD STAGE SLOPE - Slope of the third straight line segment

BIT CUTTING FORCE PARAMETERS *

50	CUTTING FORCE INTERCEPT - Intercept for the cutting force versus cut depth equation, cutting in coal
51	CUTTING FORCE SLOPE - Slope for the cutting force versus cut depth equation, cutting in coal
52	RB CUTTING FORCE INTERCEPT - Intercept for the cutting force versus cut depth equation, cutting in rock
53	RB CUTTING FORCE SLOPE - Slope for the cutting force versus cut depth equation, cutting in rock
54	FIRST STAGE END POINT (PCT) - Defines the end of the first straight line segment of the wear function for cutting force
55	FIRST STAGE INTERCEPT - Intercept of the first straight line segment
56	FIRST STAGE SLOPE - Slope of the first straight line segment
57	SECOND STAGE END POINT (PCT) - Defines the end of the second straight line segment of the wear function for cutting force
58	SECOND STAGE INTERCEPT - Intercept of the second straight line segment
59	SECOND STAGE SLOPE - Slope of the second straight line segment
60	THIRD STAGE END POINT (PCT) - Defines the end of the third straight line segment of the wear function for cutting force
61	THIRD STAGE INTERCEPT - Intercept of the third straight line segment
62	THIRD STAGE SLOPE - Slope of the third straight line segment

* from laboratory and/or In-Seam Tester data

APPENDIX C.–SAMPLE DATA

Element Number	Data Element Name	Value
1	DRUM DIAMETER (IN)	44.5
2	DRUM WIDTH (IN)	124
3	DRUM WEIGHT (LBF)	40000
4	DRUM CENTER DISTANCE (IN)	144
5	CENTER GRAVITY DISTANCE (IN)	108
6	NUMBER OF SCROLLS	1
7	DRUM REVOLUTIONS (RPM)	51
8	AVAILABLE DRUM TORQUE (FT-LBF)	40000
9	AVAILABLE THRUST (LBF)	33000
10	SEAM HEIGHT (IN)	79
11	ROCK BAND TOP	95
12	ROCK BAND BOTTOM	95
13	PCT SILICA - ROCK BAND	75
14	BREAKOUT ANGLE	115
15	SWELL FACTOR	1.5
16	FIRST DUST PARAMETER	5.0E+07
17	SECOND DUST PARAMETER	2.5E+07
18	COMPRESSIVE STRENGTH (PSI)	4000
19	GRINDABILITY INDEX	90
20	MAX. SUMP RATE (IN/S)	2.75
21	MAX. SHEAR RATE (IN/S)	3.23
22	SUMP DISTANCE	18
23	ENTRY WIDTH (IN)	144
24	BITS PER SCROLL	20
25	NUMBER OF KERF LINES--END	3
26	NUMBER OF KERF BITS--END	9
27	END KERF SECTION WIDTH (IN)	9
28	NUMBER OF KERF LINES--CHAIN	12
29	NUMBER OF KERF BITS--CHAIN	12
30	CENTER CHAIN SECTION WIDTH (IN)	24
31	AIRFLOW (CFM)	4000
32	DUST SUPPRESSION (PCT)	33
33	PRODUCTION TIME PER SHIFT (PCT)	20
34	COST PER BIT ($)	2.5
35	COST PER KILOWATT-HR ($)	.06
36	BIT LIFE (ST)	130
37	NORMAL FORCE INTERCEPT	0
38	NORMAL FORCE SLOPE	260
39	NORMAL FORCE INTERCEPT (RB)	0
40	NORMAL FORCE SLOPE (RB)	500
41	FIRST STAGE END POINT (PCT)	25
42	FIRST STAGE INTERCEPT	1
43	FIRST STAGE SLOPE	.12
44	SECOND STAGE END POINT (PCT)	50
45	SECOND STAGE INTERCEPT	2
46	SECOND STAGE SLOPE	.08
47	THIRD STAGE END POINT (PCT)	100
48	THIRD STAGE INTERCEPT	6

49	THIRD STAGE SLOPE	0
50	CUTTING FORCE INTERCEPT	0
51	CUTTING FORCE SLOPE	250
52	CUTTING FORCE INTERCEPT (RB)	0
53	CUTTING FORCE SLOPE (RB)	450
54	FIRST STAGE END POINT (PCT)	25
55	FIRST STAGE INTERCEPT	1
56	FIRST STAGE SLOPE	.06
57	SECOND STAGE END POINT (PCT)	50
58	SECOND STAGE INTERCEPT	1.5
59	SECOND STAGE SLOPE	.04
60	THIRD STAGE END POINT (PCT)	100
61	THIRD STAGE INTERCEPT	2.5
62	THIRD STAGE SLOPE	.02

* U.S. GOVERNMENT PRINTING OFFICE: 611-012/00,079

INT.-BU.OF MINES,PGH.,PA. 28918